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COMPARISON OF RIMSTOP (RETAIL INVENTORY MANAGEMENT STOCKAGE POLICY) TO CURRENT RETAIL INVENTORY POLICIES

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US Army Materiel Systems Analysis Activity
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A comparison by simulation is made between the RIMSTOP (Retail Inventory Management Stockage Policy) to current Army stockage procedures. Results indicate RIMSTOP expended fewer dollars than the current procedures to obtain the same customer satisfaction level. Also, stockage turbulence can be significantly reduced by extending the demand base used in depth and breadth decisions to two years. Currently a one year base is used.

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SUMMARY

1. Objective

The Inventory Research Office was tasked by the Logistics Management Center to evaluate the impact of implementing RIMSTOP (Retail Inventory Management Stockage Policy) for the Division Level ASLs (Authorized Stockage Lists). RIMSTOP is the Department of Defense's (DoD) standard retail level stockage policy for all Services as defined in Department of Defense Instructions (DoDI) 4140.44, .45, .46. Of particular interest to the Logistics Center was the impact of RIMSTOP on dollar investment, customer satisfaction, mobility, and ASL turbulence.

2. Methodology

Current retail stockage policies, Army Regulation 710-2, and the RIMSTOP model were compared by simulating stockage decision and replenishment actions using three years of customer requisitions for the 82nd Airborne Division, Ft. Bragg, NC.

3. Results

The RIMSTOP model outperforms the current retail policy in dollar investment for an equal customer satisfaction rate. Mobility is also improved due to the reduction in on-hand weight and cube.

To meet customer satisfaction levels achieved by the AR 710-2 model, RIMSTOP invested 26% fewer dollars in the requisition objective. The RIMSTOP ASL had 44% more lines stocked than the AR 710-2 ASL, but overall depth of stockage was reduced.

An early detriment to the RIMSTOP model was an increase in ASL turbulence (the number adds and deletes during one year expressed as a percentage of the ASL size) by 43% over the 23% turbulence under AR 710-2. However, if a two year or longer demand base is used in RIMSTOP, the ASL turbulence drops to 7%.

The simulator does not duplicate all factors that may affect stockage investments and performance. Order and Ship Times (OST) are assumed to be a constant 30 days. Actual OST, however, may take on a large range of values. In Appendix B, it is shown that the variability of this process has no significant impact on availability for the RIMSTOP model within realistic OST values.

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CHAPTER I

SIMULATOR AND DATA BASE

1.1 Simulator

The simulator used to compare the stockage models was designed to duplicate operations of the division's support activities as set forth in AR 710-2. Three years of supply activity were recreated using the first year to establish initial ASLs, and the last two for collecting performance statistics used to compare the stockage policies.

The demand rates from year three of the data base were used in the AR 710-2 basic policy to establish an initial ASL and stockage level at day zero of the simulation. With this starting point, the simulation is run under AR 710-2 for one year before statistics are collected on the model being tested. The purpose of the "warmup" is to recreate an "actual" ASL environment (breadth, on hand and backordered stocks) before collecting performance statistics.

Each item is processed through three years of time-sequenced inventory events. (Figure 1). Events occurring on the same day are processed in the following order.

(a) Due-in

(b) Customer Requisition

(c) Levels and Stockage Review

(d) ASL Requisitions (replenishment and passing orders)

The performance statistics collected for the two years of model testing are shown in Appendix A. The use of these statistics in evaluating model performance is discussed in the next chapter.

1.2 Data Base

Three years of customer (units with Prescribed Load List (PLL)) demand history by month from DLOGS (Division Logistics System) file, ID# X05AGK, was collected from the 82nd Airborne Division, Ft. Bragg, NC. Excluded from this file are Quick Supply Store (QSS) and Direct Exchange (DX) repairable activity. These items will not be managed using RIMSTOP procedures. From this data, the demand history by ASL was formed by combining demand history by stock number and supporting Direct Support Unit (DSU).

Demand histories for the forward DSUs were combined with the main DSU. The resulting data base was three years of demand histories for three DSUs: Main, Aircraft, and Missile.

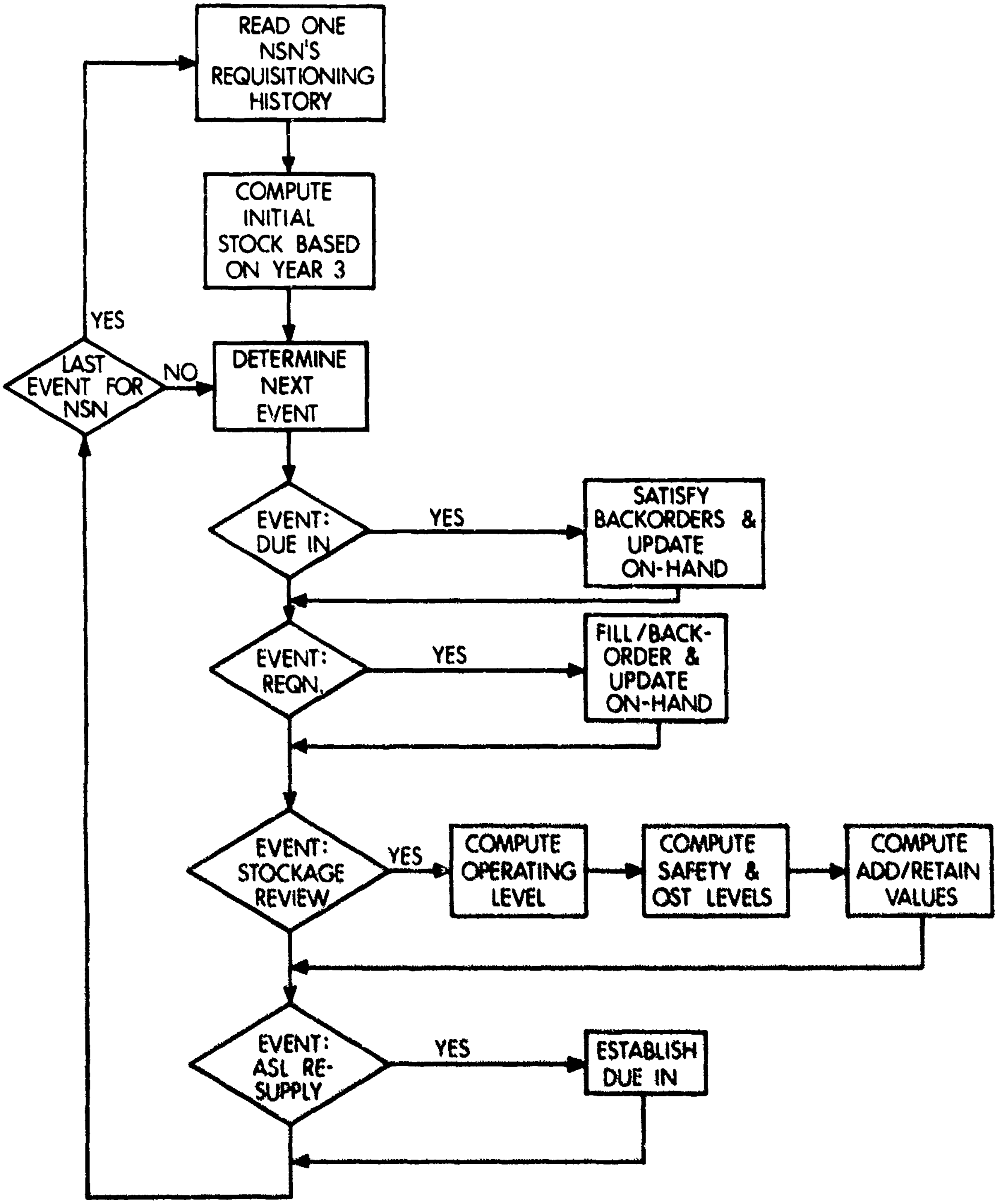

Figure 1. Simulator Logic Design.

To get necessary catalogue data such as weight/cube, unit price, and item essentiality, the ASL demand tape was matched to the AMDF (Army Master Data File) for each NSN (National Stock Number). Items not matching the AMDF were dropped from the data base.* The resulting tape had 36,000 DSU/item stock records with at least one demand in the three year period.

The final data processing step was to create the customer requisition events (PLL requisition date and quantity) for use in the simulation. By stock number, each requisition recorded for a given month was randomly assigned a julian date during that month. Next the quantity for that month was randomly distributed over the requisitions. In both cases, a uniform random number generator was used to assign the date and quantity for the requisition. Each requisition had at minimum a quantity of one unit. There were 403,000 customer requisition events on the final simulation input data tape for the three year period.

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*Because we are simulating stockage policies using a common data base instead of comparing RIMSTOP to actual performance at Ft. Bragg, those dropped items would not impact the conclusions made in the report.

CHAPTER II

MODEL EVALUATION

Inventory models are evaluated by comparing supply support per unit of resource expended. Within this framework, there are many justifiable measures each highlighting different aspects of the supply system. Measures are chosen for their accuracy and usefulness in answering basic questions of the study sponsor.

2.1 Customer Wait (CW) vs Total Cost

The supply support statistic, CW, reflects how long on average the using organization, PLL, (Prescribed Load List) waits to have a requisition completely filled. Total cost consists of the cost associated with operating an ASL. The costs are:

(a) Holding on-hand Inventory (40% of unit price) per year

(b) Adding an item to the ASL ($10)

(c) Deletion from the ASL ($30)

(d) Maintaining an item on the ASL ($30) per year

(e) Processing ASL resupply requisitions ($4.50)

(f) Processing non-ASL requisitions ($6.67)

These cost parameters were those originally used by the Department of Defense (DoD) RIMSTOP working group. (Ref 1)

2.2 Dollar Value of Requisition Objective (RO) Versus Gross Availability

This measure was chosen as a direct measure of inventory dollars expended and the percentage of requisitions filled. The dollar value of the Requisition Objective is recorded at set time intervals. Gross availability, requisitions filled divided by requisitions submitted, is the average fill rate over two years of simulation.

An auxiliary measure obtained in these runs was the weight and cube of the RO when both models tested had equal gross availabilities. This allowed a valid means for addressing the impact of the stockage decision on mobility.

The "best" model is desirably robust for both of these measures. When using either measure, either the supply support level or resource expenditure is held constant between the models tested. Results shown in this report are made by holding the supply support level constant in both policies tested and comparing resources expended.

CHAPTER III

MODEL DESCRIPTION

3.1 AR 710-2 Basic

Until October of 1980, Ft. Bragg used the AR 710-2 basic policy. The safety level and Add/Retain criteria are fixed parameters set to achieve performance targets but with no minimization of costs. The operating level is the standard economic order quantity (EOQ) which minimizes the sum of costs of holding and ordering an operating level.

a. Add/Retain - 3/1 aircraft, missile items (three requisitions per year to add to the ASL, 1 requisition, to remove from the ASL)

6/3 common items

b. Order Ship Time (OST) - 30 days of supply

c. Safety Level - 15 days of supply

d. Operating Level - $EOQ = \sqrt{\frac{2DA}{IC}}$

where A = ordering cost ($4.50)

D = annual demand rate

I = inventory holding cost (40% of the average on hand dollar value/ year.)

C = item's unit price

3.2 AR 710-2 Variable Class IX

After October 1980, Ft. Bragg, 82nd Airborne implemented the variable class IX policy as developed by the Logistics Center. This policy incorporates the essentiality of the item in setting Add/Retain parameters to achieve target availability.

a. Add/Retain

	Aircraft	Missile	Common
Essential	7/1	3/1	6/1
Non-Essential	10/2	3/1	11/3

b. Safety level, OST, and operating level are computed as in AR 710-2 basic.

3.3 RIMSTOP

RIMSTOP is a variable inventory policy where the decision values for Add/Retain (breadth) and the levels computations (depth) are based on individua.

item characteristics such as item cost, demands, variability, etc. The model evaluates the cost tradeoff between stocking and not stocking items to arrive at decision parameters which minimize total cost for a given performance level.

The RIMSTOP model has two modules, one for calculating the operating and safety levels, and the other for determining an item's add/retain criteria. These modules are linked by a shortage cost parameter, LAMBDA (λ), which is used to regulate the depth and breadth of stockage. Raising the λ improves performance and raises operating costs. The λ value is computed* so as to meet desired availability targets for each direct support unit and item essentiality grouping. In the simulation, the λ value was adjusted to establish a baseline cost or performance value equal to the AR 710-2 policy being tested.

a. Add/Retain**

$$\text{Add} = \frac{F + CH + CA + CO}{(\lambda + CXN) - \mu\ (\lambda + CXS)}$$

$$\text{Retain} = \frac{F + CH - CR + CO}{(\lambda + CXN) - \mu\ (\lambda + CXS)}$$

where

F = Fixed cost of stocking on item

CH = cost to hold the average on hand inventory

CA = cost to add an item to the ASL

CO = ordering cost for 1 year

CXN = cost to process a non-stocked requisition

CXS = cost to process a stocked requisition

CR = cost to remove an ASL item

λ = shortage cost ($/requisition short)

μ = 1 - availability

b. Safety Level

Safety level = $a\sigma$

$$a = -\frac{1}{\sqrt{2}}\left[\ln\left[\frac{\sqrt{2}(OL)(H)(U)(S)/\sigma}{.5(\lambda)(1-e^{-\sqrt{2}\frac{(OL)}{\sigma}})}\right]\right]$$

$$\sigma = .769 \times \sqrt{OST} \times AMD$$

---

* The procedures to calculate λ values can be found in Ref (1).

** The minimum spread between the add and retain was forced to be one (i.e. A/R = 3/3 becomes A/R = 3/4) in lieu of adding a variable cost to remove. This decision was made by the DA Staff based on simulations made by IRO.

where

OL = operating level (EOQ)

H = holding cost

U = unit price

S = average requisition size

λ = shortage cost

AMD = average monthly demand

OST = order and ship time

c. The OST and operating levels are computed as in AR 710-2 basic and variable class IX.

CHAPTER IV

RESULTS

4.1 Comparison of AR 710-2 Basic to RIMSTOP

The AR 710-2 basic policy was first run to establish a baseline gross availability. The RIMSTOP model was then run for several LAMBDA values until the same availability was achieved. Results are presented below in Table 1.

TABLE 1

	710-2 Basic	% Change	RIMSTOP
Availability	.671	Baseline	.673
Accommodation	.768		.776
Satisfaction	.863		.861
$ RO	1,641,647	-31.7%	1,121,040
ASL Lines	5635	+38.4%	7804
ASL Turbulence	43.6%	-7.7%	40.2%
ASL Weight (lbs)	298,639	-19.7%	239,752
ASL Cube (cu. ft.)	15,138	-15.7%	12,754

To achieve the same stock availability as AR 710-2 Basic, RIMSTOP stocks more ASL lines but at a lesser depth. No adverse impact on mobility results from the additional ASL lines since weight and cube drop.

These results demonstrate the minimization of cost at a fixed availability resulting from the RIMSTOP optimization technique. A Catalog analysis of PLL requisitioning patterns indicates the customers order "small" quantities for a large range of NSNs. By stocking more ASL lines, RIMSTOP satisfies more requisitions than AR 710-2 Basic, but the depth of stockage remains low because of the "small" PLL order sizes.

4.2 Comparison of AR 710-2 Variable Class IX and RIMSTOP

Using the same technique as before, the two models are set at the same baseline availability rate. Results are shown in Table 2.

TABLE 2

	710-2 Variable IX	% Change	RIMSTOP
Availability	.6526		.652
Accommodation	.7423		.7625
Satisfaction	.8646		.855
$ RO	1,411,197	-26.6%	1,035,318
ASL Lines	4715	+44%	6792
ASL Turbulence	24.2	+43%	34.7%
ASL Weight	271,812	-18%	233,014
ASL Cube	13,180	-10.5%	11,799

The conclusions from the previous comparison also apply here. ASL size is increased under RIMSTOP but the dollar value, weight and cube of the RO decreases. One difference from the previous comparison is the large increase in turbulence for the RIMSTOP model over 710-2 Variable Class IX. Turbulence, however, is more a function of the ASL size rather than a property of the breadth model. When the λ value is lowered to stock the same number of items as 710-2 Variable Class IX, the turbulence rates are approximately equal.

The results shown in Tables 1 and 2 are shown graphically (Fig 2) by plotting gross availability against RO dollars for each model. With the RIMSTOP model, a range of Availability/$ RO points can be plotted by varying the LAMBDA value thus producing a curve. With this graph, exact baseline comparison are made; thus the percentage change figures are slighly different from Tables 1 and 2 where approximate baselines were found.

4.3 Comparison of AR 710-2 Basic, AR 710-2 Variable IX and RIMSTOP Using the Total Cost vs Customer Wait (CW)

The measure $ RO to availability uses the closing $ RO figure at the end of the second year of simulation. "On hand dollars" is also measured at the end of the simulation. The total cost measure computes averages over the two years of simulation to find total cost and customer wait time. Table 3 displays the individual elements for each model used in computing total cost and CW. Figure 3 is a graphical display of these results. Again, RIMSTOP outperforms both AR 710-2 policies using this measure.

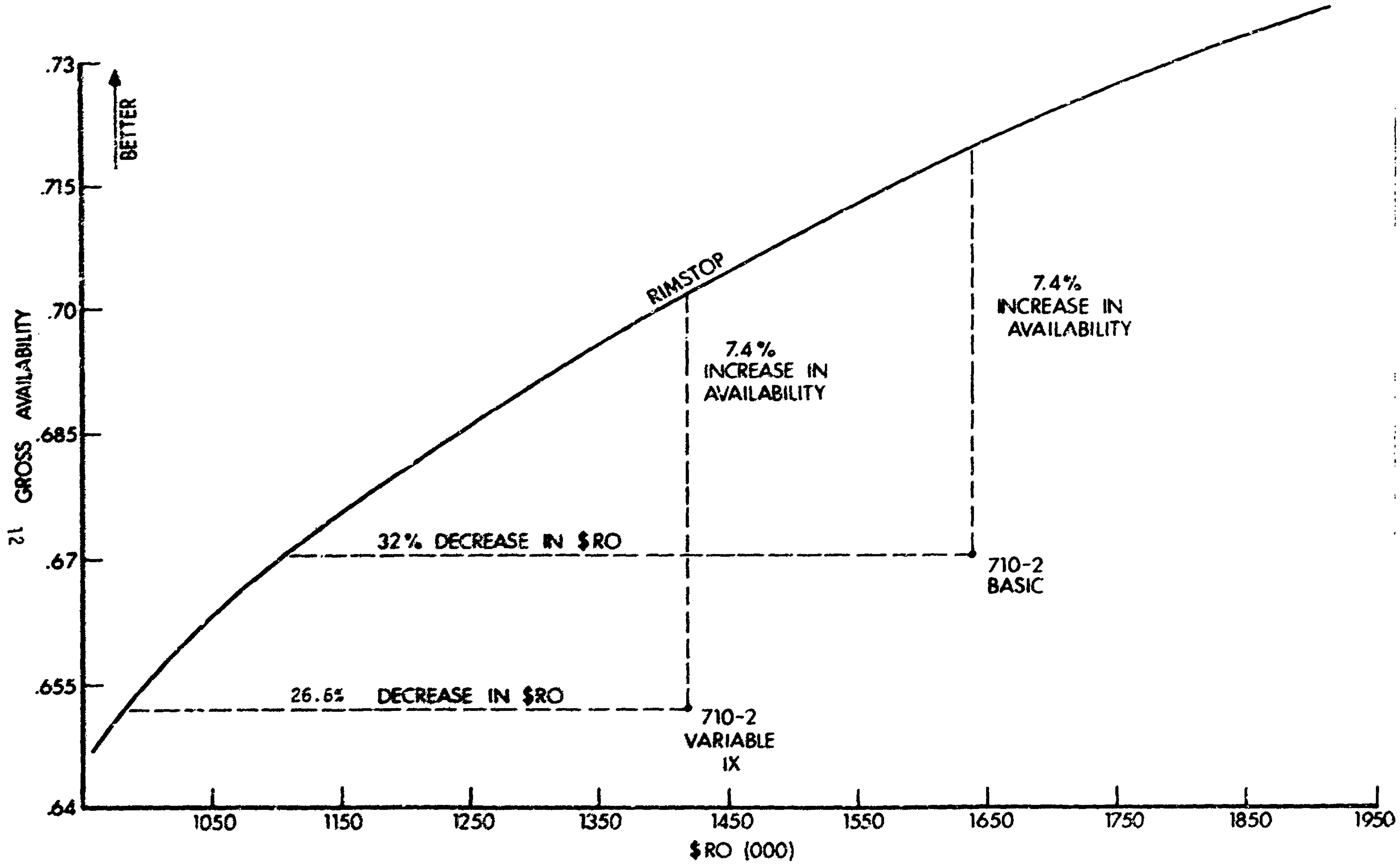

Figure 2. $RO vs Gross Availability.

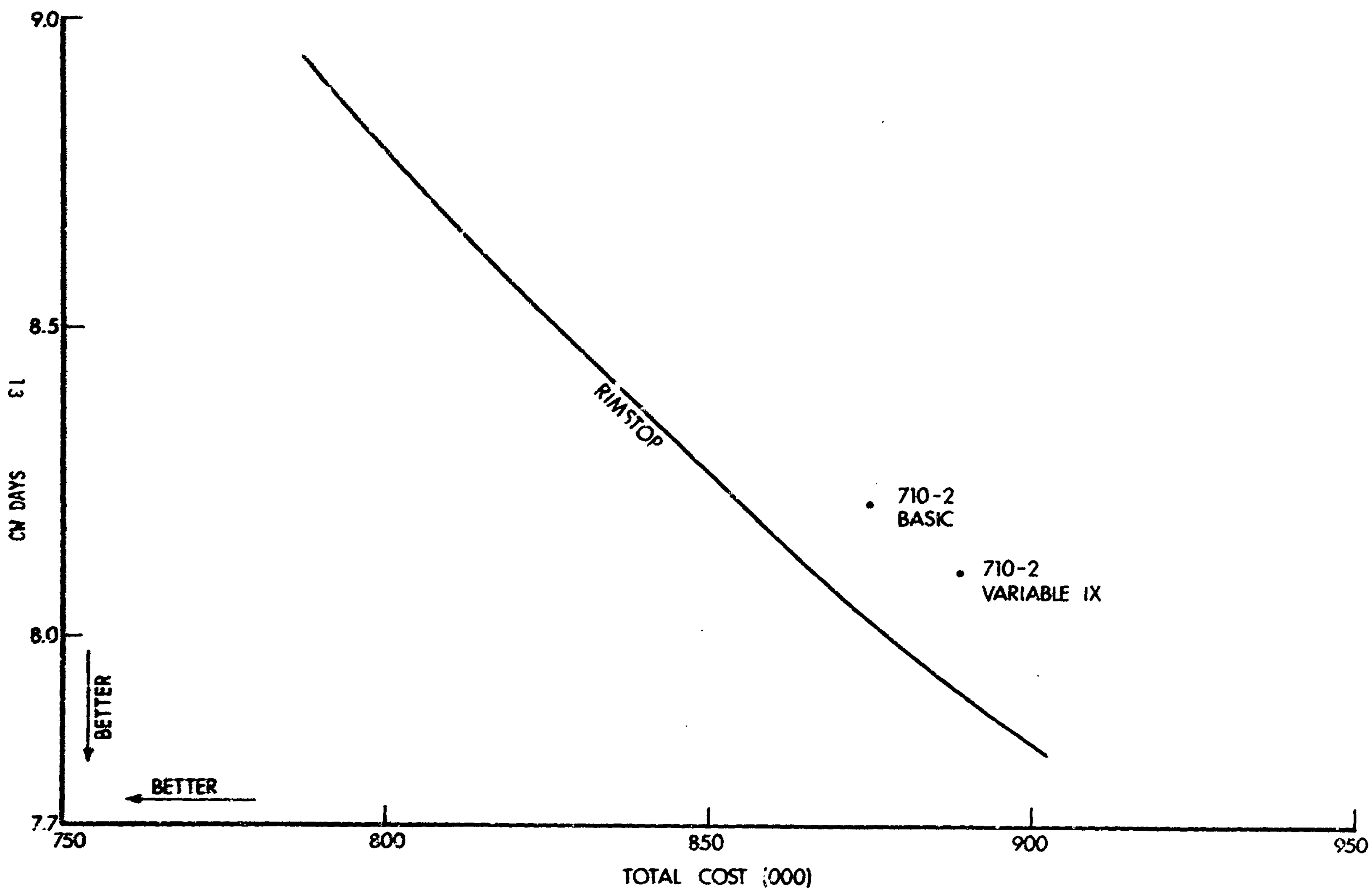

Figure 3. CUSTOMER WAIT VS TOTAL COST

The percentage change between the policies however is not as dramatic as when using the $ RO to availability measures. This is because RIMSTOP stocks more items resulting in a high turbulence rate. The $ RO measure does not reflect turbulence as a resource expenditure while Total Cost does. Chapter V addresses enhancements to RIMSTOP to reduce turbulence.

TABLE 3

	710-2	710-2 Variable IX	RIMSTOP
On Hand Dollars	1,037,113	1,128,140	850,167
No. ASL Lines	5487	5250	7151
No. Stocked Orders	14,930	10,964	15,672
No. Non-Stocked Orders	27,849	29,014	26,822
No. ASL Adds	1261	939	2212
No. ASL Deletions	1031	937	980
Total Cost	875,933	889,117	855,543
Customer Wait	8.315	8.215	8.33

CHAPTER V

USE OF LONG FORECAST BASES TO REDUCE RIMSTOP ASL TURBULENCE

5.1 Problem

In comparing the RIMSTOP model to the Variable Class IX and AR 710-2 models, turbulence increased by a factor of 1.43 to a 35% annual rate under RIMSTOP. Several modifications were made to the Basic RIMSTOP model in an attempt to reduce turbulence. The costs to add and delete ASL lines was doubled thus reducing turbulence to 25% with little degradation in performance. Stockage reviews were made semi-annually as opposed to reviews when levels dropped below the Reorder Point (ROP). This had little impact on turbulence. The most successful enhancement was increasing the forecast base over the one year currently used by DLOGS/DS4.

5.2 Rationale for Longer Base Periods

Stockage turbulence is caused by erratic demand patterns on individual line items. An analysis of Ft. Bragg catalogue shows these erratic patterns (Figure 4). Only 25% of the NSNS which had at least one demand in the three year data base had at least one requisition each year. These items account for 83% of the requisitions. The remaining 75% of the lines accounting for 17% of the requisitions had no demands in one or two of the three years observed. Individual item demand streams frequently show a spurt of requisitioning over a short time horizon followed by no activity.

A short forecast base reacts quickly to the spurt of activity by stocking the item, then as quickly destocks the item. Longer bases smooth out the demand stream thus reducing turbulence. The potential disadvantage of using a long base period, is the model's inability to adjust quickly to a genuine change in demand patterns. The simulation evaluates this trade-off by comparing cost and performance of the long vs short forecast bases.

5.3 Model

a. Short Base: Basic RIMSTOP model using a one year demand forecast.

b. Longer Base: Basic RIMSTOP model. Forecast based on all available history at the time of a stockage review or levels recomputation. Therefore, after the one year warmup, the initial forecast is one year; at the end of the simulation the forecasts are based on three years of history. The average forecast base therefore is two years.

		YEAR				
# ITEMS	%	1st	2nd	3rd	# REQUISITIONS	%
5886	16	0	0	1	9648	2
4747	13	0	1	0	6379	2
3211	09	0	1	1	15896	4
7689	21	1	0	0	11578	3
2443	07	1	0	1	9879	2
2948	08	1	1	0	16310	4
9146	25	1	1	1	333815	83

0 = No Demands in the Year

1 = 1 or More Demands in the Year

FIGURE 4

ILLUSTRATION OF ERRATIC DEMAND PATTERNS

5.4 Evaluation of the Model

Comparison of alternative models is generally made by comparing RO dollars to gross availability and total operating cost (holding + ASL maintenance, adds, deletes stocked and non-stocked orders) to customer wait time. Both of these measures were viable when comparison were made of the 710-2/Variable IX model of the RIMSTOP's policy. However, several inadequacies surface during the evaluation of base periods.

When using the $ RO to gross availability as a measure, the reduction in turbulence is not totally reflected in the RO or availability measure (Table 4). Still, the longer base period produces a better performance (gross availability) per RO dollar and less excess material than the one year base.

TABLE 4

	ONE YEAR	LONGER BASE
Items	6675	6530
RO $	1,035,318	1,104,130
Accommodation	.766	.769
Net Avail	.8502	.8647
Gross Avail	.6524	.6706
Turbulence	35.7%	5.7%
Excess (Quantity over RO plus 2 years of demand)	511,480	185,493

The second measure, total cost to customer wait time, does reflect the reduction in ASL turbulence. However another shortcoming of the measure surfaces: total cost does not include the cost incurred when full credit is not received on excess material. The highly turbulent one year forecast is shedding on-hand inventory by excessing stocks, thus reducing the holding cost element of total cost.

The correct adjustment to the total cost measure would be to charge for lost dollars on items for which full credit was not received. Estimates from various sources places the figure near 50%. However it is difficult to set an exact figure because credit policies are based on the source of supply and the stockage levels of the activity receiving the excess.

An easier solution was to eliminate the excess rule thereby charging a 40% holding cost to the on-hand inventory. The following model comparison will be made with no excess allowed in the system.

5.5 Results

The following comparison was made by selecting a shortage cost (LAMBDA) so that each model would have similar customer wait time. The best model is the one with the lowest total cost.

TABLE 5

	1 Year Forecast	Longer Forecast
ASL Size	7861	7789
$ On Hand	1,301,255	1,187,150
Accommodation	.7893	.7902
Net Availability	.8658	.8653
Gross Availability	.6955	.6968
Turbulence	43%	7.3%
Customer Wait	7.71	7.61
Total Cost	1,065,180	965,555

These results can be shown graphically (Figure 5) where the lower curve is the "best" policy.

Turbulence is drastically cut from 43% to 7% when a long forecast base is used. ASL size and on hand dollars are also reduced.

5.6 Conclusion:

Dramatic reductions in ASL turbulence is achieved by using a forecast base longer than one year. Also the dollar value of excess material is significantly reduced. No reduction in performance is observed.

5.7 Implementation

Within DLOGS and DS4, (Direct Support Unit Standard Supply System) extending the demand base over the current one year would require file restructuring. SAILS (Standard Army Intermediate Level Supply Subsystem) does maintain exponentially smoothed demand and requisition frequency values, based on all data collected on the item. These values should be used as input to the RIMSTOP model.

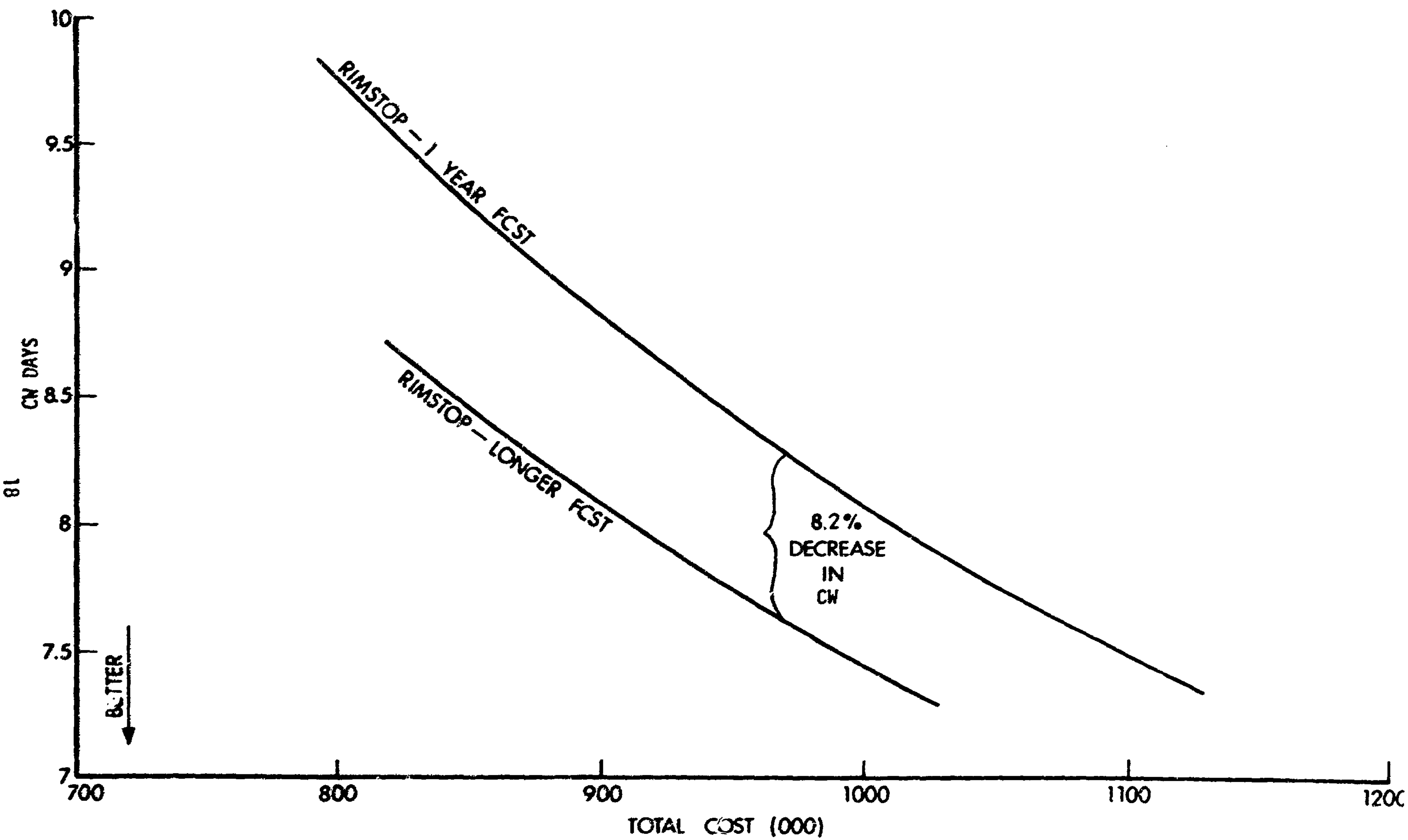

Figure 5. CUSTOMER WAIT VS TOTAL COST (No Excess Rule)

APPENDIX A

SIMULATOR OUTPUT

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***********************************O******************
 FIRST     YEAR STATS
121670. NUMBER OF REQUISITONS
92287.  NUMBER OF REQUISITIONS FOR STOCKED
79421. SATISFIED  REQUISITIONS FOR STOCKED
80650. SATISFIED REQUISITIONS FOR ALL
 ACCOMODATION = .7585025067806
 NET AVAIL= .8605870816041
 GROSS AVAIL = .6628585518205
 QTY REQUISITIONED = 999180
 DOLLAR VALUE OF REQUISITIONS = 7309469.859004
 UNIT B/O DAYS = -15352006
 UNIT DAYS WAIT = 15.36460497608
 DOLLAR B/O DAYS = -136036652.5533
 DOLLAR OH DAYS = 322109732.6484
26791 NON STOCKED ORDERS
13305 STOCKED ORDERS

 FIRST     YEAR CLOSING POSITION
           STOCKED ITEMS
6459 ITEMS STOCKED
922460.4599926 DOLLAR VALUE RO
129731.1553105 DOLLAR VALUE SL
669153.0799951 DOLLAR VALUE OH
-80466.97999996 DOLLAR VALUE BO
101760.3599987 WEIGHT OF RO
9067.582999925 CUBE OF RO
120870.6499992 WEIGHT OF OH
6171.390999953 CUBE OF OH

            NON STOCKED ITEMS
110367.30 DOLLAR VALUE OH
 435579.5099973 DOLLAR VALUE BO
4669.33 WEIGHT OF OH
289.255 CUBE OF OH
```

```
****************************************************
SECOND     YEAR STATS
135805. NUMBER OF REQUISITONS
104049.  NUMBER OF REQUISITIONS FOR STOCKED
88463. SATISFIED  REQUISITIONS FOR STOCKED
88606. SATISFIED REQUISITIONS FOR ALL
 ACCOMODATION = .7661647214756
 NET AVAIL= .8502051917846
 GROSS AVAIL = .6524502043371
 QTY REQUISITIONED = 1113184
 DOLLAR VALUE OF REQUISITIONS = 10210280.66846
 UNIT B/O DAYS = -18459962
 UNIT DAYS WAIT = 16.58302850203
 DOLLAR B/O DAYS = -241355327.727
 DOLLAR OH DAYS = 264000770.1519
30714 NON STOCKED ORDERS
15452 STOCKED ORDERS

SECOND     YEAR CLOSING POSITION
            STOCKED ITEMS
6792 ITEMS STOCKED
1035318.639992 DOLLAR VALUE RO
171454.8139675 DOLLAR VALUE SL
938768.739992 DOLLAR VALUE OH
0. DOLLAR VALUE BO
223014.4799985 WEIGHT OF RO
11799.44199991 CUBE OF RO
179341.8899988 WEIGHT OF OH
9566.805999926 CUBE OF OH

             NON STOCKED ITEMS
11653.27 DOLLAR VALUE OH
0. DOLLAR VALUE BO
1127.43 WEIGHT OF OH
56.574 CUBE OF OH
```

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****************************************************************
TOTAL     YEAR STATS
257475. NUMBER OF REQUISITONS
196336.  NUMBER OF REQUISITIONS FOR STOCKED
167884. SATISFIED  REQUISITIONS FOR STOCKED
169256. SATISFIED REQUISITIONS FOR ALL
 ACCOMODATION = .7625439363045
 NET AVAIL= .8550851601336
 GROSS AVAIL = .6573686765705
 QTY REQUISITIONED = 2112364
 DOLLAR VALUE OF REQUISITIONS = 17519750.52517
 UNIT B/O DAYS = -33811968
 UNIT DAYS WAIT = 16.00669581568
 TW REQ. SHORT-NONSTOCK =29.28165328187
 TW REQ. SHORT-STOCK = 2.391711148236
 TW REQ. SHORT-ALL = 8.776890960287
 EXCESS TURN IN STOCKED = 8107.919999990
 EXCESS TURN IN NON-STK = 503373.239999
 DOLLAR B/O DAYS = -377391980.2613
 DOLLAR ON DAYS = 586110502.7419
57705 NON STOCKED ORDERS
28757 STOCKED ORDERS
****************************************************************

 FIRST     YEAR STOCKED DATA
6133.402777778 ITEMS STOCKED (DAY WT)
604 ITEMS ON TO OFF
1756 ITEM OF TO ON
30 ITEM ON TO OFF TO ON

SECOND     YEAR STOCKED DATA
6675.955555556 ITEMS STOCKED (DAY WT)
999 ITEMS ON TO OFF
1332 ITEM OF TO ON
26 ITEM ON TO OFF TO ON
```

APPENDIX B

ORDER SHIP TIME VARIABILITY

1. In comparing the various stockage models, the simulator used a fixed order and ship time of 30 days. In reality, OSTs are variable times with an unknown distribution but with a known mean value.* The following analysis indicates that OST variability does not significantly impact stocked item availability within reasonable OST values, thereby eliminating the need to simulate the OST distribution or include the variability in the safety level computation.

2. Using the basic RIMSTOP model with the safety level, EOQ and OST quantities based on 30 days, four simulator runs were made with actual fixed OST values of 20, 30, 40, and 50 days. The resulting stocked item availability was plotted against the actual OST (Figure B1). Visually, this relationship appears to be a straight line, that is, avail = a + b (OST). If this is true, the variability of the OST process has no impact on availability and only the mean value needs to be considered to meet an availability target.

3. Proof

Assume $A = a + b \cdot (OST)$ as observed from the line in B(1) using deterministic OSTs.

Where A = Availability

OST = Actual OST Time for each replenishment

a,b = Parameters of the linear equation inherent to RIMSTOP model and the data base.

Now let the actual OST times vary for each replenishment action.

Let p(x) be any probability distribution for OST with known mean, $\overline{OST}$, and unknown variance.

$\bar{A} = \Sigma A \cdot (p(OST))$ where the sum is taken over for all possible OST values

$$= \Sigma\ [a + b \cdot (OST)] \cdot p(OST)$$

$$= a \cdot \Sigma\ p(OST) + b \cdot OST \cdot p(OST)$$

$$= a + b \cdot \overline{OST}$$

*DS4 captures all OST values and derives an average OST for levels computations.

Therefore, the availability line obtained with the deterministic OST values, would be the same if we simulated with probability OST times.

4. We next verify these results and the assumption of the linearity of availability and OST using the simulator.

Simulator runs were made with three 2 point uniform OST distributions [20,40], [10,50], and [5,55]. If the assumptions hold, we should be able to predict the availability from these runs with the expression a + b $(\overline{OST})$. The results are as follows:

OST Distribution	OST	Predicted A = a+b $(\overline{OST})$	Actual Avail From Simulator	Percent Difference
[20,40]	30	.861	.857	-.34%
[10,50]	30	.861	.850	-1.3%
[5,55]	30	.861	.846	-1.7%

As the OST variability increases, so does the difference between the predicted and actual values though not significant. The difference is due to the OST variability impact on availability, which was not part of the linear equation used to predict availability.

5. These same conclusions were reached in an earlier IRO Study (Reference 7). Actual OST times for Korea were used in an evaluation of safety level performance using various empirical estimates of OST variance. Actual values for OST ranged from three to 13 months. OST variance estimates of two to six months were evaluated. With this wide range of OST variability, the effect of this factor on the safety level for a particular availability was small.

The conclusions presented here are applicable to the current RIMSTOP model as simulated and implemented within DS4. Should the probability distribution of lead time demand or the safety level constraints be modified, the impact of OST variability may change.

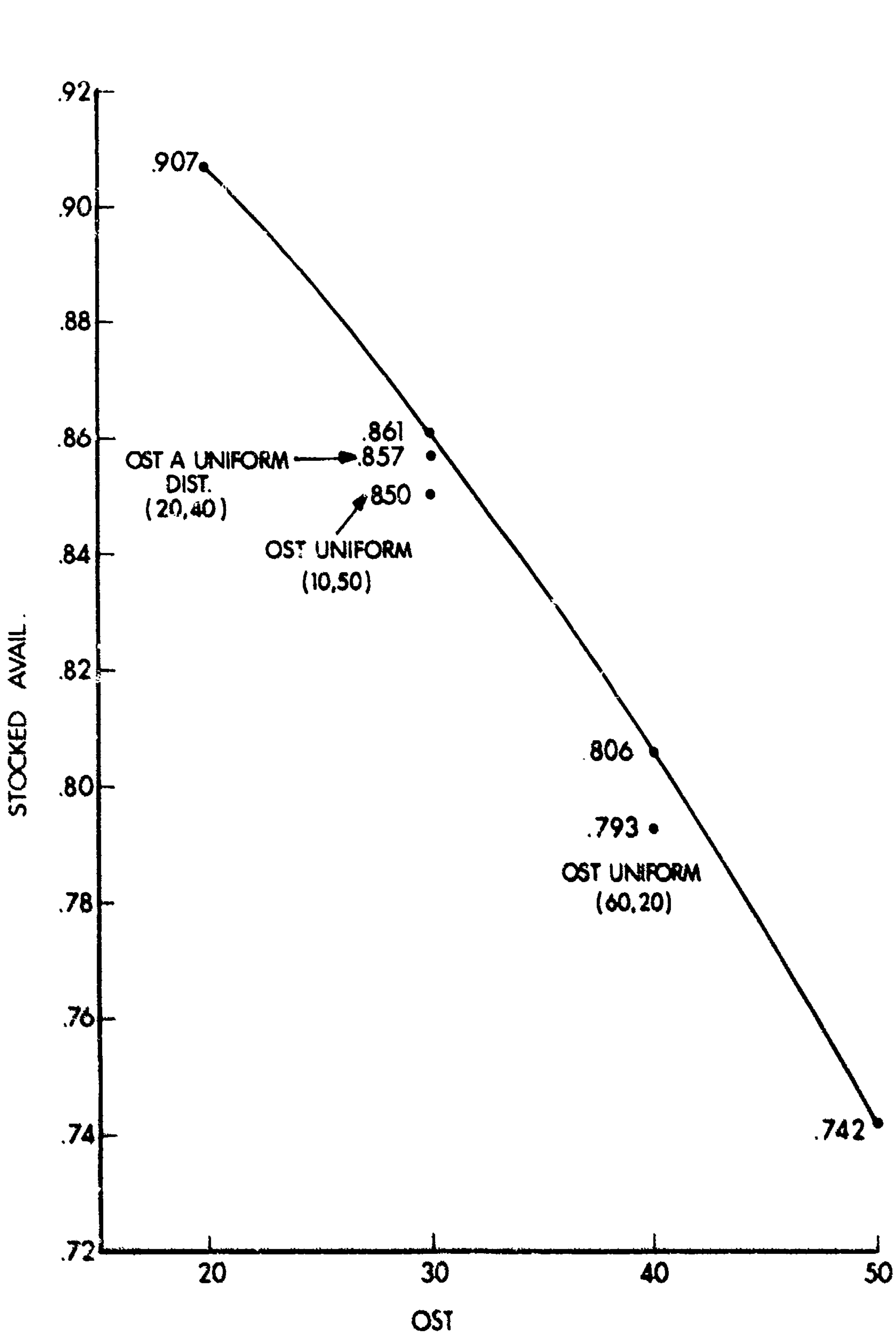

Figure B1. Comparison of Performance for Fixed and Variable OSTs.

GLOSSARY OF TERMS

Accommodation:

The percentage of demands placed on a stock point for stocked items.

Availability (Net):

The percentage of requisitions satisfied for stocked items.

Availability (Gross):

The percentage of stocked and non-stocked requisitions filled at a stock point (Net Availability x Accommodation = Gross Availability).

Customer Wait:

Average Time in days required to satisfy customer (PLL) requisitions.

Turbulence:

A count of movement of items on and off a stockage list. Defined as: the number of additions and deletions over a year divided by the average ASL size.

BIBLIOGRAPHY

1. "DoD Retail Inventory Management and Stockage Policy," Volumes I, II, III, Office of the Secretary of Defense Installation & Logistics, September 1976.

2. AR 710-2 "Material Management for Using Units, Support Units and Installations, August 1971.

3. Deemer, R. L., "Developing Requisition Short Cost Parameters for RIMSTOP," Final Report, Inventory Research Office, November 1981, to be published.

4. DoD Directive 4140.44 "Management of the Intermediate and Consumer Levels of Inventory," 7 April 1978.

5. DoDI 4140.45 "Standard Stockage Policy for Consumable Secondary Items at the Intermediate and Consumer Levels of Inventory," 7 April 1978.

6. Variance Class IX Authorized Stockage List (ASL) Add/Retain Policy for Division Support Command," US Army Logistics Center, Ft. Lee, VA, 1 July 80.

7. Chern, Chung-Mei, "An Empirical Approach to Variable Safety Levels for Army Overseas Theaters," Inventory Research Office, May 1972, AD745397.

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